

SEMI D82-0821

TEST METHOD FOR VIEWING ANGLE OF FLAT PANEL DISPLAYS

This Standard was technically approved by the Flat Panel Display - Metrology Global Technical Committee.
This edition was approved for publication by the global Audits and Reviews Subcommittee on April 30, 2021.
Available at www.semiviews.org and www.semi.org in July 2021.

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1 Purpose

1.1 The viewing angle characteristic of display panel is one of the most important optical performance relevant to viewing directional image quality.

1.2 Viewing angle means the maximum angle at which a display is viewable with acceptable visual performance according to the specified viewing angle threshold.

1.3 This Standard introduces how to calculate and decide viewing angles for the viewing directional performance of flat panel displays which are viewing angles related to tone reproduction and color reproduction as well as conventional contrast viewing angle.

1.4 Test methods with new viewing angle thresholds are suggested which decides the viewing angle of displays based on the variation of gray scale and chromaticity as well as half-luminance and half-contrast under the darkroom condition.

2 Scope

2.1 This Standard is applicable to test viewing angle of flat panel displays such as TV and monitor under the darkroom.

2.2 The scope of the term ‘viewing angle’ is related to acceptable visual performance such as contrast, gray scale, and chromaticity variation in this Standard.

2.3 This Standard defines only horizontal and vertical viewing angles for measurement.

NOTICE: SEMI Standards and Safety Guidelines do not purport to address all safety issues associated with their use. It is the responsibility of the users of the Documents to establish appropriate safety and health practices, and determine the applicability of regulatory or other limitations prior to use.

3 Referenced Standards and Documents

3.1 SEMI Standards and Safety Guidelines

SEMI D71 — Test Method of PDP Tone and Color Reproduction

SEMI D76 — Test Method for Viewing Angle Characteristic Using Reference Color on Visual Displays

3.2 ITU-R Publications¹

Recommendation ITU-R BT.709 — Parameter Values for the HDTV Standards for Production and International Programme Exchange

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3.3 IEC Standards²

IEC TS 62977-3-1 — Electronic Displays – Part 3-1: Evaluation of Optical Performances – Colour Difference Based Viewing Direction Dependence

3.4 ISO Standards³

ISO 9241-305:2008 — Ergonomics of Human-System Interaction – Part 305: Optical Laboratory Test Methods for Electronic Visual Displays

3.5 SID Standards⁴

IDMS v1.03B — Information Display Measurements Standard

NOTICE: Unless otherwise indicated, all documents cited shall be the latest published versions.

4 Terminology

4.1 Abbreviations and Acronyms

4.1.1 *APL* — average picture level

4.1.2 *DUT* — device under test

4.1.3 *FOV* — field of view

4.1.4 *LMD* — light measuring device

4.2 Definitions

4.2.1 *CIELAB* — a uniform color space defined by the CIE in 1976, officially known as CIE L*a*b*. L* stands for luminance, a* is the red-green axis, and b* is the blue-yellow axis.

4.2.2 *color difference* — the Euclidean distance between two colors in a specific color space.

4.2.3 *measuring distance* — the distance between display screen center and front edge of noncontact LMD's main body at the measuring position.

4.2.3.1 *Discussion* — In case of noncontact LMD, it is recommended as three times of the screen height. It is different from the viewing distance that is recommended according to the display resolution.

4.2.4 *viewing angle* — the maximum angle of viewing direction (scalar in degree) to the normal direction which satisfies the specified threshold for acceptable visual performance in horizontal or vertical viewing directions.

NOTE 1: The angle of viewing direction is also often called viewing angle in working-level while the maximum acceptable viewing direction is called viewing direction range (see SEMI D76, ISO 9241-305:2008 and IEC TS 62977-3-1).

4.2.5 *viewing direction* — the directional viewing condition that describes the horizontal and vertical inclination direction (vector direction) to the normal direction to the plane of the display surface.

4.2.5.1 *Discussion* — This Standard adopts right-handed x-y-z Cartesian coordinates with origin at the center of the screen. It is also called measuring direction.

4.2.6 *wide viewing angle* — the viewing angle specification which is greater than the maximum angle of vantage point viewing direction in all viewing angles for contrast, gray scale, and chromaticity in horizontal or vertical viewing direction.

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³ International Organization for Standardization, ISO Central Secretariat, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland; Telephone: +41.22.749.01.11, <http://www.iso.org>

⁴ The Society for Information Display, 1475 S. Bascom Ave. #114 Campbell, CA 95008-4006 USA, <http://www.sid.org>

5 Summary of Test Method for Viewing Angle

5.1 Measuring Conditions

5.1.1 Environmental Conditions

5.1.1.1 The following environmental conditions are required to make accurate measurements.

- Temperature: $25 \pm 2^\circ\text{C}$.
- Humidity: 25% to 85% relative humidity.
- Air flow: no wind.
- Dark room: All measurements shall be carried out in a dark room normally under 1 lux.

5.1.1.2 When any of these conditions is not met, they shall be noted on the report.

5.2 Measurement Setup

5.2.1 The measuring equipment shall consist of device under test (DUT), contact or noncontact light measuring device (LMD), signal generator, and control PC (if used) as shown in Figure 1. In this Standard, measuring location on the screen is always the screen center of the display.

5.2.2 Measuring Distance

5.2.2.1 It is recommended that the measuring distance of noncontact LMD is set to include over 500 pixels of display within 2° field of view (FOV) in normal direction. For the terminology of noncontact LMD, refer to Figure 2 (see § 3.7 in IDMS v1.03B).

5.2.2.2 When measuring at a viewing direction with noncontact LMD as shown in Figures 3 and 4, if FOV is not satisfied or the measurement diameter exceeds the pattern area, the measuring distance could be shortened so that the pattern area would be larger than the FOV. If the measuring distance is not three times of the screen height, it should be noted on the report.

5.2.2.3 Generally, the measuring distance is recommended to be consistent regardless of the resolution of display because the video content resolution and screen shape is various such as curved displays. If the measuring distance is not three times of the screen height in case of noncontact LMD, it should be noted on the report.

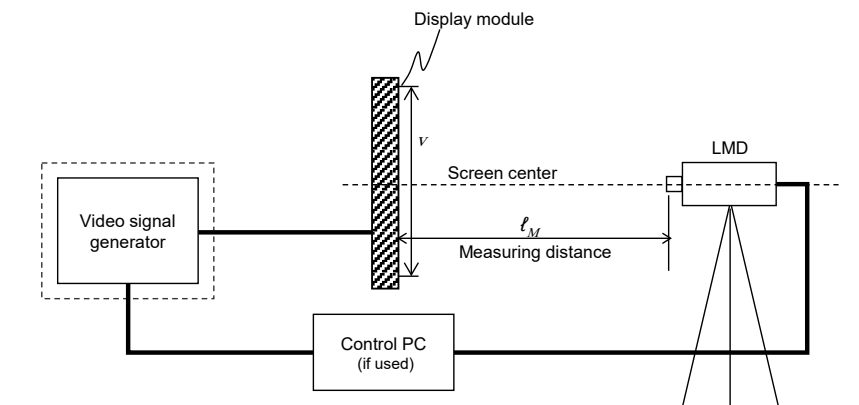


Figure 1
Measurement Setup with Noncontact LMD

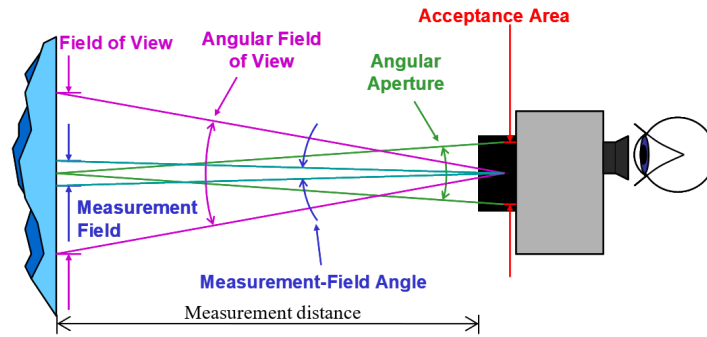


Figure 2
Measurement Setup with LMD Terminology

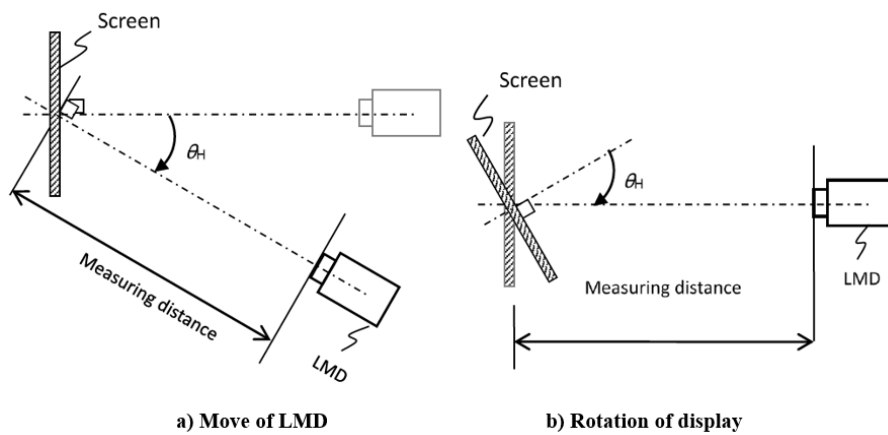


Figure 3
Measurement Setup in Horizontal Viewing Direction (Top View)

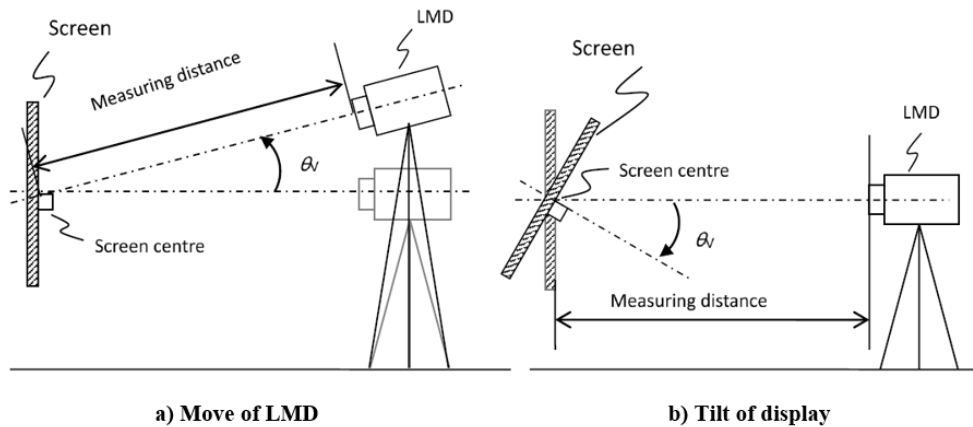


Figure 4
Measurement Setup in Vertical Viewing Direction (Side View)

5.2.3 Viewing Direction

5.2.3.1 The viewing direction is specified by horizontal θ_H and vertical θ_V as shown in Figures 3 and 4.

5.2.3.2 The horizontal and vertical viewing directions (θ_H , θ_V) are defined as θ_H (-60° , -45° , -30° , -15° , 0° , 15° , 30° , 45° , 60°) and θ_V (-60° , -45° , -30° , -15° , 0° , 15° , 30° , 45° , 60°), respectively, where minus sign (-) means leftward (θ_L) or downward direction (θ_D), and plus angle means rightward (θ_R) or upward (θ_U).

5.2.4 Optical Measuring Devices

5.2.4.1 In this Standard, an LMD such as spectroradiometer, filter photometer or colorimeter shall be used for photometry and colorimetry.

5.2.4.2 It requires the photometric accuracy of the LMD within $\pm 2\%$ and chromaticity accuracy within ± 0.002 for x,y.

5.2.5 Warm-Up Time

5.2.5.1 Warm-up shall be achieved before measurement and it must ensure that the luminance approaches a stable value.

5.2.5.2 This warm-up time shall be longer than 30 minutes or follow the instructions determined by manufacturer.

5.2.6 Darkroom Condition

5.2.6.1 All measurements shall be carried out in the darkroom condition with illumination less than 1 lux. Or the luminance contribution from the background illumination reflected off the test display shall be less than 1/20 the display's black state luminance. If it is not satisfied, it shall be reported.

5.2.6.2 When a different illuminance or ambient illumination condition is used, it shall be noted on the report.

5.3 Measurement Patterns

5.3.1 Patterns for Contrast Viewing Angle

5.3.1.1 For the measurement of contrast viewing angle, the 5×5 checkerboard pattern shall be used as shown in Figure 5, which the average picture level (APL) is 52% and 48%, respectively.

5.3.1.2 The two test patterns are adopted to avoid possible dimming and boosting functions for peak contrast of the display in highlighted area.

5.3.2 Pattern for Gray Scale Viewing Angle

5.3.2.1 For the measurement of gray scale viewing angle, the 4% area gray box pattern is used as shown in Figure 6.

5.3.2.2 The background signal level shall be black, that is, 0% signal level. When the display luminance is dependent on APL, the window size could be reduced to 1% area ($1/10H \times 1/10V$) as long as the area is enough to be measured. In that case, it shall be noted on the report.

5.3.2.3 8 bit and 10 bit R, G, and B input codes for 11 or 17 gray levels are shown in Table 1.

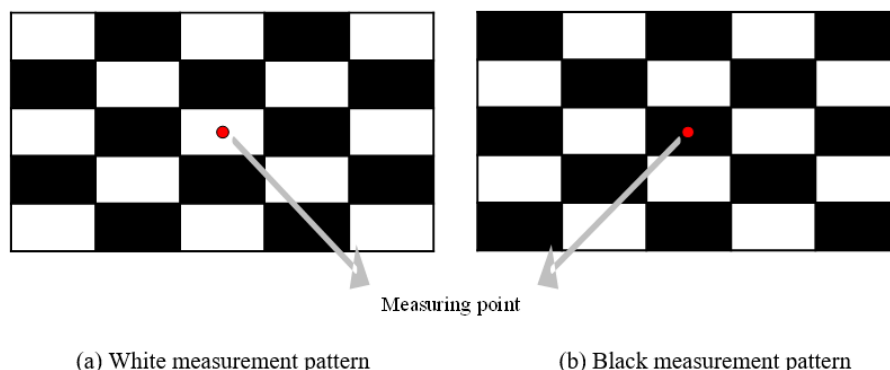


Figure 5
Checkerboard Pattern for Contrast Viewing Angle Measurement

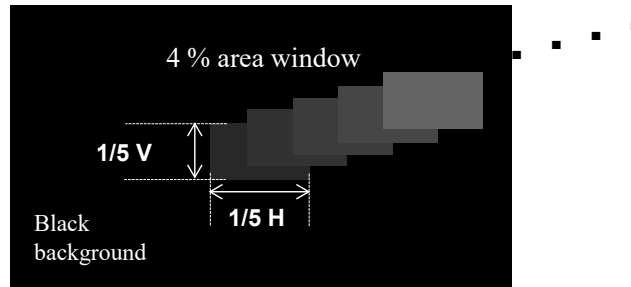


Figure 6
Gray Box Pattern for Gray Scale Viewing Angle Measurement

Table 1 RGB Input Codes for Gray Scale Measurement

Input No. (i)	10 Inputs (V_i)		16 Inputs (V_i)	
	10 bit	8 bit	10 bit	8 bit
1	0	0	0	0
2	102	25	64	15
3	205	51	128	35
4	307	76	192	47
5	409	102	256	63
6	512	127	320	79
7	614	153	384	95
8	716	178	448	111
9	818	204	512	127
10	921	229	575	143
11	1023	255	639	159
12			703	175
13			767	191
14			831	207
15			895	223
16			959	239
17			1023	255

5.3.3 Pattern for Chromaticity Viewing Angle

5.3.3.1 For the measurement of chromaticity viewing angle, 4% area window pattern is used as shown in Figure 7.

5.3.3.2 The background signal level shall be black, that is, 0% signal level. When the display luminance is dependent on APL, the window size could be reduced to 1% area ($1/10H \times 1/10V$) as long as the area is enough to be measured. In that case, it shall be noted on the report.

5.3.3.3 8 bit (0 to 255) R, G, and B input codes for the 24 reference color patches in ITU-R BT.709 color gamut are shown in Table 2.